MODIS Atmosphere QA Plan

Version 2.0
December, 1999

Prepared by

MODIS Atmosphere Team

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1.0 Introduction

Quality assessment is an important element in the sequential data reduction from Level 0 raw counts to Level 1B calibrated radiance, and continually to Level 2 granuled and Level 3 gridded products. The Level 2 MODIS atmosphere products are physically-retrieved from the MODIS measurements and grouped into a user-friendly HDF file based upon the categories of aerosols, clouds, column water vapor, atmospheric profiles and cloud mask. The Level 3 joint atmospheric product contains hundreds of 1°??1° gridded parameters in a single HDF file and each parameter is associated with a number of statistical quantities (mean, standard deviation, histogram and regression). We believe that the quality assessment is sufficiently available from the statistics calculated by 1°??1° spatial aggregation. No specified QA information is provided in Level 3 product. This document describes the QA (quality assessment or quality assurance) plan, including QA approach, QA network systems, QA scenarios, Level 2 runtime QA (structure and information content), and post-processing quality evaluation using both Level 2 and Level 3 atmosphere products.

The MODIS Level 2 and Level 3 atmosphere products (product ID) are listed as follows:

- Aerosol over land and ocean (MOD04)
- Total precipitable water at Near IR and IR wavelengths (MOD05)
- Cloud and cloud top properties (MOD06)
- Temperature and moisture profiles (MOD07)
- Cloud mask (MOD35)
- Daily, 8-day and monthly global map (MOD08 D3, MOD08 E3, MOD08 M3)

Each Level 2 atmospheric parameter is retrieved at a spatial resolution determined by the sensitivity of retrieval, not necessarily on a single FOV basis. The runtime QA flags are designed to store the flags of processing path, input data source, and the estimated quality of the physical parameters retrieved. Commonly used by all atmospheric products are the cloud mask flags derived at 1?1 km resolution for the determination of cloudy and clear pixels. The QA metadata, on the other hand, are to report statistics calculated based upon a granule of data in the form of either inventory or archive metadata. The inventory metadata are searchable whereas the archive metadata are for documentation only.

The post-processing QA is to diagnose atmosphere Level 2 and Level 3 products using the runtime QA flags and metadata and also to evaluate data quality (leading to the update of science quality flag) by intercomparisons with climatology (such as the maximal and minimal values) or other available sources of satellite or ground measurements if possible. This process involves visualization of the products, documentation (e.g., product log) of daily images and simple statistical analysis (e.g.,

time series). The success of quality evaluation relies on effective QA netwrok systems for processing, transfer and storgage of the MODIS massive data volume (250 GB L1B and 35 GB L2 and L3 atmosphere products).

1.1 QA Network Systems

The MODIS atmosphere QA network involves GDAAC (Goddard Distributed Active Archive Center), MODAPS (MODIS Data Processing System) and Windhoek (MODIS Atmosphere Centralized Computing Facility), which are depicted in Figure 1. The Windhoek system will be devoted heavily to QA activities along with local SCFs. The MOD04, MOD05 and MOD06 products will be generated at MODAPS by MODIS PI processing and MOD35 and MOD07 products will be produced at GDAAC. All the MODIS atmosphere L2 and L3 products (~35 GB per day) will be pushed through a fiber-optic link (100 Mbits per second) to Windhoek when the newly processed data is available. It is planned that Windhoek will store up to 400 GB MODIS atmosphere L2 and L3 products (approximately 10-14 days residing time) for QA purpose. Level 3 products will be kept online up to a year. Not shown in Figure 1 are the upper stream of data transfer from EDOS to GDAAC and down stream of data distribution from Windhoek to MODIS data validation team members.

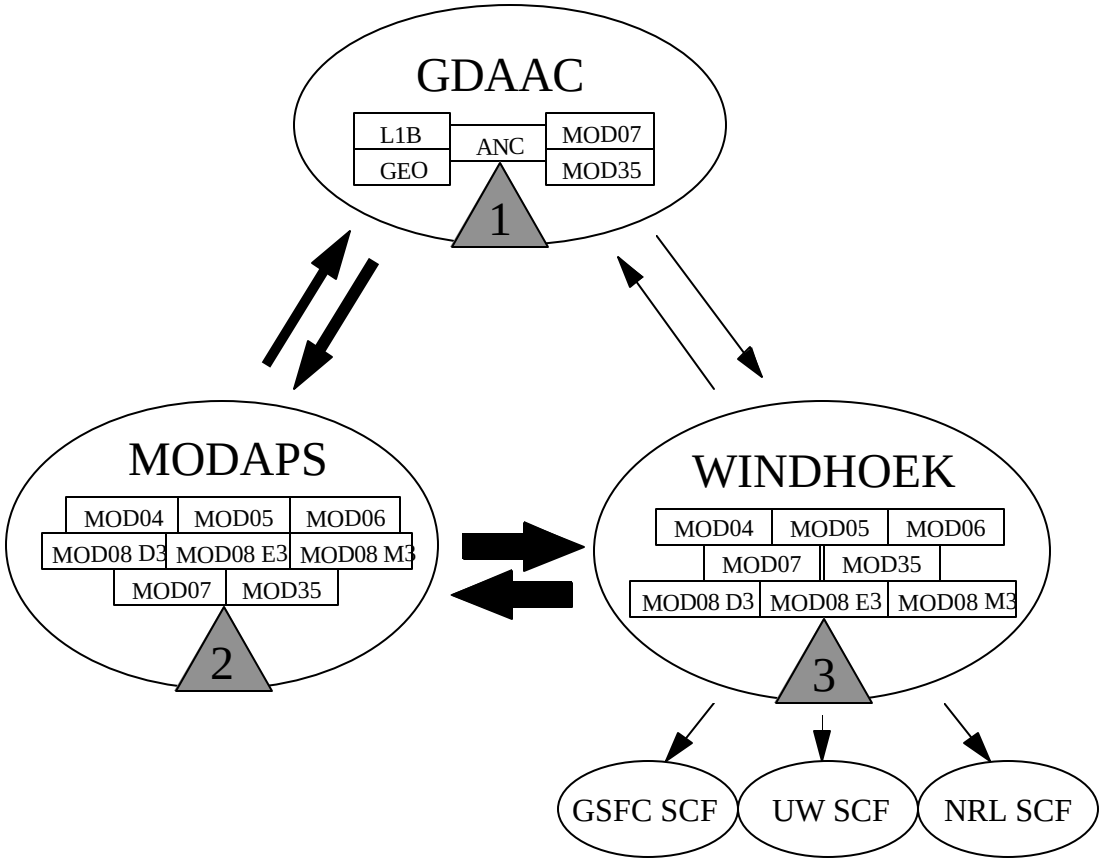


Figure 1. QA network systems for MODIS atmosphere products

Network Systems (SGI Origin 2000)	Number of CPUs	RAM (GByte)	DiskSpace (TBytes)
MODAPS	112	28	-
Windhoek	8	2	1.165

The role of GDAAC, MODAPS and SCF personnel are illustrated as follows:

• Due to MODIS massive data volume, the operational process at GDAAC (e.g., the link between EDOS and GDAAC) should maintain the highest quality level possible to ensure the data uncorrupted during production, transfer, and archival. The role of GDAAC personnel is to ensure the correct functioning of the operational data production processes, the integrity of the data derived, and availability of production logs. The GDAAC personnel will not perform any science QA for MODIS atmospheric products of MOD07 and MOD35 produced at GDAAC.

• The role of MODAPS personnel is to monitor the daily MODIS atmosphere Level 2 and Level 3 products (MOD04, MOD05, MOD06, MOD08-D3, MOD08-E3, and MOD08-M3) pushed to Windhoek for uncorrupted data transmission between MODAPS and Windhoek. The MODAPS personnel should provide prompt instruction and assistance if needed. The MODAPS personnel will not perform any science QA for MODIS atmospheric products. In an attempt to establish efficient communication and trouble handling, the Windhoek system adminstrator was hired to work closely with MODAPS personnel in Building 32 at NASA Goddard Space Flight Center.

• The role of SCF personnel is to perform post-processing QA using MODIS atmosphere Level 2 and Level 3 products on WINDHOEK. The details will be discussed in Section 3. The Windhoek system adminstrator has the overall responsibility for data transmission, storage and archival. In addition, he will assist science team member to develop an effective QA visualization system.

1.2 QA Approach

The (automatic) operational and (automated) post-production approaches forms the key to the QA process of MODIS atmosphere products. The former encompasses the runtime QA flags and metadata produced in each products as well as the operational procedures performed in real time at the GDAAC or MODAPS (MODIS Data Processing System). The latter shows the post-production data quality evaluation process centralized at Windhoek.

The runtime QA flags produced in Level 2 products are the central piece of the quality assurance plan. They are designed not only to report success or failure of criteria being used in retrieval but also to estimate the data quality. The resolution-level QA flags provide much more detailed information and thus provide better information to produce Level 3 global products. The MODIS atmosphere Level 3 products are produced to include various statistical quantities (e.g., mean, standard deviation, histogram and regression). Theoretically, in evaluating the quality of the retrieval, the quality of the inputs should also be considered. However, it is a too much complex process. Thus, the Level 2 QA flags are to reflect only the product itself, with input sources flagged for later evaluation. The structure/information content of runtime QA flags and metadata can be found in section 2, followed by detailed tabulation of QA flags and metadata in Appendices A, B and C, respectively. Listed below is the table of the size of QA flags (in byte) implemented in MODIS atmosphere Level 2 products.

Level 2 Product ID	Level 2 Product Name	Spatial Resol. (km x km)	QA flags Size (bytes)
MOD04	Aerosol properties	10x10	8
MOD05	Total precipitable water	1x1 & 5x5	6
MOD06	Cloud and cloud top properties	1x1 & 5x5	15
MOD07	Atmospheric profiles	5x5	9
MOD35	Cloud mask	1x1	10

An automated visualization system for the Level 2 and Level 3 products is the goal for routine post-processing QA. A suite of visualization software is under development based upon IDL (e.g., Paint the Globe). This complete system is designed to easily access the atmospheric parameters of interest as well as the runtime QA flags and metadata. Through subsetting by reducing the size of the data enables the comparison with ground measurements for the update science quality flag. The AERONET of 100 sites of photometers all over the world provide aerosol optical thicknesses from 0.38 to 1.02 ?m, which is an attempt to using real-time observations for QA purpose. After launch, a centralized QA effort at NASA Goddard Space Flight Center should greatly enhance the post-processing QA effort by prompt interaction and communiation among atmospheric discipline groups. Intercomparison of results from other available satellite and ground-based will help us to gain experience and improve the algorithms. Overall, the post-processing QA is considered to be a part of validation effort.

1.3 QA Scenarios

Event	Descrption	DAAC/MODAPS	SCF
1	PGE Starts	Active	-
2	PGE crashes	•Graceful crash - Notify SCF personel •Ungraceful crash - if core dump, rerun PGE with debugging mode on	•Graceful crash - examine the exit code information, possibly rerun PGE •Ungraceful crash: diagnose the results generated from debugging mode
3	PGE creates granule	•Monitoring the whole PGE process •Notify SCF personel if needed (TBD)	-
4	Successful PGE runs	•Monitored by DAAC •Sort out the nature and severity of non-fatal errors if occur •Notify SCF if needed (TBD)	• Examine the non-fatal error due to exit code information
5	Data Server Insert	•Monitored by DAAC •Troubling shooting if fails •Notify SCF if needed (TBD)	-
6	Investigative QA	•Set operational quality flag •Monitoring processing log files (or examing QA ESDTs) if any abnormalies occur •Notify SCF personel if not due to operation	•Notified by DAAC, or discovered while doing routine QA •Requesting processing log files •Detailed procedures to be determined.
7	Routine QA	•B.0 - active but does not do any data quality evaulation except updating QA science quality flag •B.1 - passive	•Do routine QA as specified in post-runtime QA procedures
8	Error analysis	•Help retrieve diagnostic files (FailedPGE ESDTS, Status, Report or User logs), or provide method to retrieve those files	•Do error analysis based upon the information gathered from diagnostic files •Procedures to be determined

1.4 Related Documents

1) EOS Data Products Handbook, Volume 1 TRMM & AM-1, S. Whatan and M. Myers, 1995.

2) Interface Control Document between EOSDIS core system (ECS) and Science Computing Facilities (SCF), EOSDIS core system project, 505-41-33, January, 1996.

3) Release B Science Data Processing Segment (SDPS) Database Design and Database Schema Specifications for ECS Project, 311-CD-008-001, EOSDIS Core System Project, May 1996.

4) Software Requirements Specification for the ECS Quality Assurance Metadata Update Utility, draft version, J. Closs, ECS, November 22, 1996.

5) The QA process: A Decomposition of Functional Elements Version 2, R. Lutz, ESDIS Science Office, March 15, 1996.

6) MODIS Science Data Processing Software Requirement Specification Version 2 and beyond, SDST, December 12, 1996.

7) MODIS Level 1B QA plan, version 1.2, MCST document #M0028, Jones et al., June 1996.

8) Science Data Validation Plan of MODIS Atmospheric Products, King et al., June 1997.

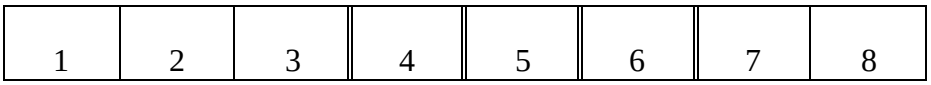
2.0 Level 2 Runtime QA Structure/Information Content

The quality of Level 2 product can be (1) inherited from the L1B radiances, or (2) associated with retrieval process. The pixel-based L1B validity flags comprising information on dead and saturated detectors, calibration failure, etc. are examined by L2 algorithms for determination of the radiometric status of each pixel. This information can prevent further calculations from being performed if criteria is not met by the given algorithm. The granule-level L1B QA metadata provides summary information for valid and saturated earth view observations, and can be useful in screening a granule of data. Details about MODIS L1B QA flags can be found in the MODIS L1B QA plan. The structure and information content of MODIS atmosphere Level 2 runtime QA are shown in the following sections.

2.1 QA flags

The SDS run time QA flags are stored based upon product resolution. For convenience, the run time QA flags can be divided into three parts: (1) cloud mask flags, (2) product quality flags, and (3) retrieval processing flags.

Cloud Mask Flags are constructed using the first byte of the cloud mask:



Bits 1-3: cloud state
(bit 1: determined / undetermined)
(bits 2-3: cloud confidence / coverage defined in percentage)
Bit 4: day / night flag
Bit 5: sun glint flag
Bit 6: snow / ice flag
Bit 7-8: land / sea flag

For products of 1?1 km resolution, the first byte of the cloud mask will be written and stored. For coarser resolution products, the information for each bit will be determined by science team members based upon the retrieval method. The cloud mask (MOD35) itself will not duplicate this information. To avoid duplication for combined products, cloud mask QA flags will be stored once. The only exception is the cloud product, where the cloud mask QA flags will be stored at both 1?1 and 5?5 km resolutions

Product Quality Flags 4 bits are used to indicate the quality of each parameter retrieved at the product spatial resolution. The first bit indicates usefulness of the

parameter, followed by 3 bits for the quality level (up to a total of 8 quality levels), such as

1	2	3	4	5	6	7	8	...	...	...	...

Bit 1: useful / not useful flag of 1st parameter
Bits 2-4: maximum eight quality levels of 1st parameter
Bit 5: useful / not useful flag of 2nd parameter
Bits 6-8: maximum eight quality levels of 2nd parameter

The total length of product quality flags is ???, where N is number of parameters retrieved of the product. In order to save space, if two parameter are derived based upon the same criteria and from the same retrieval method, the product run time QA flags can be consolidated into a sinlge 4 bits (instead of 8 bits). This should cause no confusion if it is documented properly.

Table 1 shows the data quality estimated for each atmospheric product. As an example, the data quality of the aerosol optical thickness product over land will be estimated by

$$\text{Data Quality} = \left(\frac{N}{N_o}\right)^2 \left(\frac{1}{P}\right)^{0.5} \left(1 - \frac{\sigma_{sd}}{\sqrt{N}\,\rho_{mean}}\right)^2$$

where N is the number of cloud and water free pixels, N_0 the total number of pixels in a 10?10 km grid, P the aerosol retrieval priority (=1,2,3,4) and ? the apparent reflectance. The scale factors ? and ? are yet to be determined. For cloud effective radius, the data quality may be estimated by the absolute differences of the values derived at two different spectral channels. Similarly, the quality of total precipitable water may be estimated by the difference of total precipitable water retrieved at 0.94 and 0.905 ?m wavelengths. The differences of total precipitable water at near IR and IR wavelengths, on the other hand, will be useful for data validation. These quality flags should be particularly useful in the L3 joint product development, data quality assessment and validation. QA weighted statistics of atmospheric parameters are included as part of the L3 atmosphere joint product.

Table 1. MODIS Level 2 atmospheric parameters, spatial resolution and product quality flag.

Product ID	Product Content	Resolution (km)	Product Quality Evaluatoin

MOD04	Aerosol over land (GSFC) Aerosol over ocean (GSFC)	10?10	$\left(\frac{N}{N_o}\right)^2 \left(\frac{1}{P}\right)^{0.5} \left(\frac{\sigma_{sd}}{\sqrt{n}\,\sigma_{mean}}\right)^2$
MOD05	Total precipitable water - NIR (GSFC)	1?1	$= W_{0.94\,\mu m} - W_{0.90\,\mu m}$
	Total precipitable water -IR (UW)	5?5	See MOD07
MOD06	Cloud properties (GSFC & NRL)	1?1	For example, cloud droplet effective radius $\left\| r_{1.6\,\mu m} - r_{2.1\,\mu m} \right\|$
	Cloud top properties (UW)	5?5	CTP - convergence of observations and calculated RTE solution
MOD07	Atmospheric temperature, moisture profile and offshoots (UW)	5?5	TBD
MOD35	Cloud mask (UW)	1?1	Based on number of tests perfomed

Retrieval Processing Flags are used for miscellaneous purposes. The bit length and information content are determined by the responsible science team member. In general, it may contain

- Physical, algorithm, climatological constraints
- Atmospheric correction (Rayleigh scattering, gaseous absorption)
- Input resource of ancillary data or MODIS product
- Spectral band and detector status (L1B)
- Occurrence of contamination by thin cirrus

Two types of retrieval processing flags are defined in the MODIS atmosphere QA plan, the processing path flag and the input data resource flag. The former indicates the retrieval path, the correction due to Rayleigh scattering and gaseous absorption, or the occcurrence of error during retrieval. The latter is to indicate the source of input data sets, such as other MODIS products, ancillary data from other satellites, model assimilated data from DAO (Data Assimilation Office), or NCEP (National Center for Environmental Prediction), or climatology. The information given by the flags are potentially important for post-launch quality evalulation as well as data validation. The detailed information on retrieval processing flags for each atmospheric product can be found in section 3.

2.2 QA Metadata

QA metadata consists of statistical information for a given granule of data processed. Because of space limitations, only inventory metadata will be stored by EOSDIS. All the SDS data (including QA flags) and archive metadata will be archived on tape. For clarity, the QA metadata is divided into three parts: (1) ECS core QA inventory metadata, (2) product-specific (non-ECS) QA inventory metadata, and (3) product-specific QA archive metadata.

ECS Core QA Inventory Metadata is one part of the inventory metadata used for MODIS atmosphere quality assurance. Table 2 shows the ECS general core inventory metadata implemented in MODIS atmosphere version 2 software, and includes percent missing data, science quality and operational quality flags (and their explainations in text form) specifically defined to be associated with the measured parameters of a product. The operational quality is set by the DAAC, and will not be changed. The science quality flag, however, is assigned initially by the science team, and then updated through an update utility if necessary. Percentage of missing data is planned to report the percent of missing data from L1B calibrated radiance data per granule.

Table 2. ECS Core Metadata of MODIS V2 atmospheric products.

ECS Core Attribute Name	ECS Data Type	# of Values
SHORTNAME	STRING	1
VERSIONID	STRING	1
SIZEMBECSDATAGRANULE	DOUBLE	1
REPROCESSINGACTUAL	STRING	1
REPROCESSINGPLANNED	STRING	1
LOCALGRANULEID	STRING	1
LOCALVERSIONID	STRING	1
DAYNIGHTFLAG	STRING	1
PRODUCTIONDATETIME	DATETIME	1
PGEVERSION	STRING	1
INPUTPOINTER	STRING	30(Max)
RangeDateTime		
RANGEBEGINNINGTIME	TIME	1
RANGEENDINGTIME	TIME	1
RANGEBEGINNINGDATE	DATE	1
RANGEENDINGDATE	DATE	1
Bounding Rectangle		
EASTBOUNDINGCOORDINATE	DOUBLE	1
WESTBOUNDINGCOORDINATE	DOUBLE	1
NORTHBOUNDINGCOORDINATE	DOUBLE	1

SOUTHBOUNDINGCOORDINATE	DOUBLE	1
OrbitCalculatedSpatialDomain		
ORBITNUMBER.1	INTEGER	1
EQUATORCROSSINGLONGITUDE.1	DOUBLE	1
EQUATORCROSSINGDATE.1	DATE	1
EQUATORCROSSINGTIME.1	TIME	1
MeasuredParameter		
PARAMETERNAME.1	STRING	1
SCIENCEQUALITYFLAG.1	STRING	1
SCIENCEQUALITYFLAGEXPLANATION.1	STRING	1
OPERATIONALQUALITYFLAG.1	STRING	1
OPERATIONALQUALITYFLAGEXPLANATION.1	STRING	1
QAPERCENTMISSINGDATA.1	INTEGER	1

Additional QA inventory metadata can be added by science team members to accommodate their needs. These are discussed in the next sections.

Product-Specific QA Inventory Metadata is used to accommodate the QA needs of each specific MODIS atmosphere product. The product specific QA inventory metadata includes statistics reported by either the MODIS cloud mask algorithm or by the product generation algorithm itself. For all MODIS atmosphere products, the product-specific QA inventory metadata include

- % successful rate of retrieval
- % day processed
- % night processed
- % sunglint processed
- % snow background processed
- % land processed
- % water processed
- % shadow processed
- % low confidence clear
- % miscellaneous types of cloud
- % non-cloud obstruction
- % maximum solar zenith angle
- % minimum solar zenith angle

An important feature if product-specific QA inventory metadata is it's searchability. A user can skip an entire granule of data if the requested criteria are not satisfied, or can examine the granule of data in more detail if they are satisfied. The detailed descriptions of product-specific QA inventory metadata for each of MODIS atmosphere products can be found in section 4.

Product-Specific QA Archive Metadata is designed to report the summary statistics and information of a granule for documentation purposes only. These values are not searchable. The archive metadata for each of the MODIS atmospheric products are described in section 5.

3.0 Post-Processing QA

MODIS atmosphere Level 2 and Level 3 products produced at GDAAC and MODAPS are pushed 100% to Windhoek for quality evaluation. The MODIS atmosphere post-processing QA includes routine and investigative QA processes. Routine QA includes the visualization of images, documentation, and generation of QA report. The data volume for routine QA may be reduced in a 6-month span. The investigative QA is focused on the problems as discovered in routine QA. As a part of investigative QA, all MODIS atmosphere algorithms are subject to consistency check using pre-launch MAS measurements. It is planned that during the period of centralized QA (when data becomes available), the MODIS atmosphere discipline groups will diagnose the MODIS global L2 and L3 products together at Goddard, along with fractional L1B and ancillary data. Figure 2 shows an example of the selection of L1B and ancillary data in terms of geolocaton and occurrence that significant aerosol event occurs around the globe.

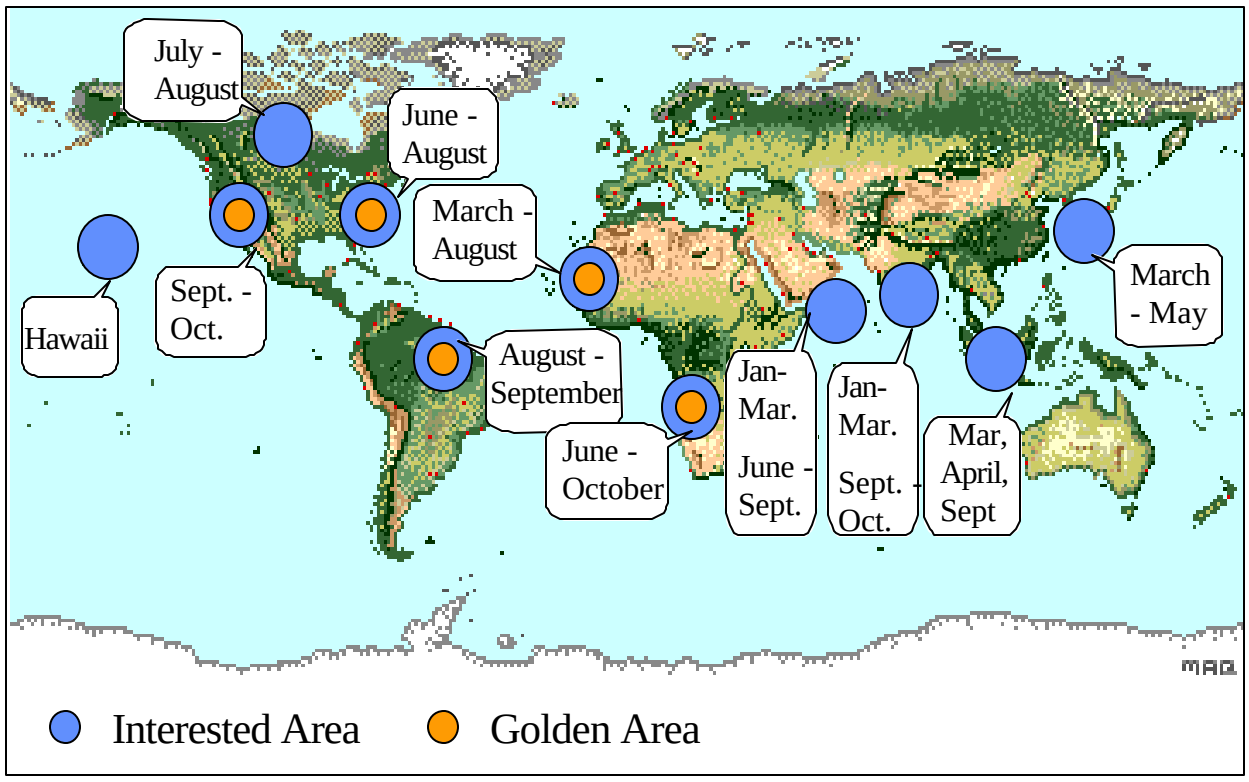


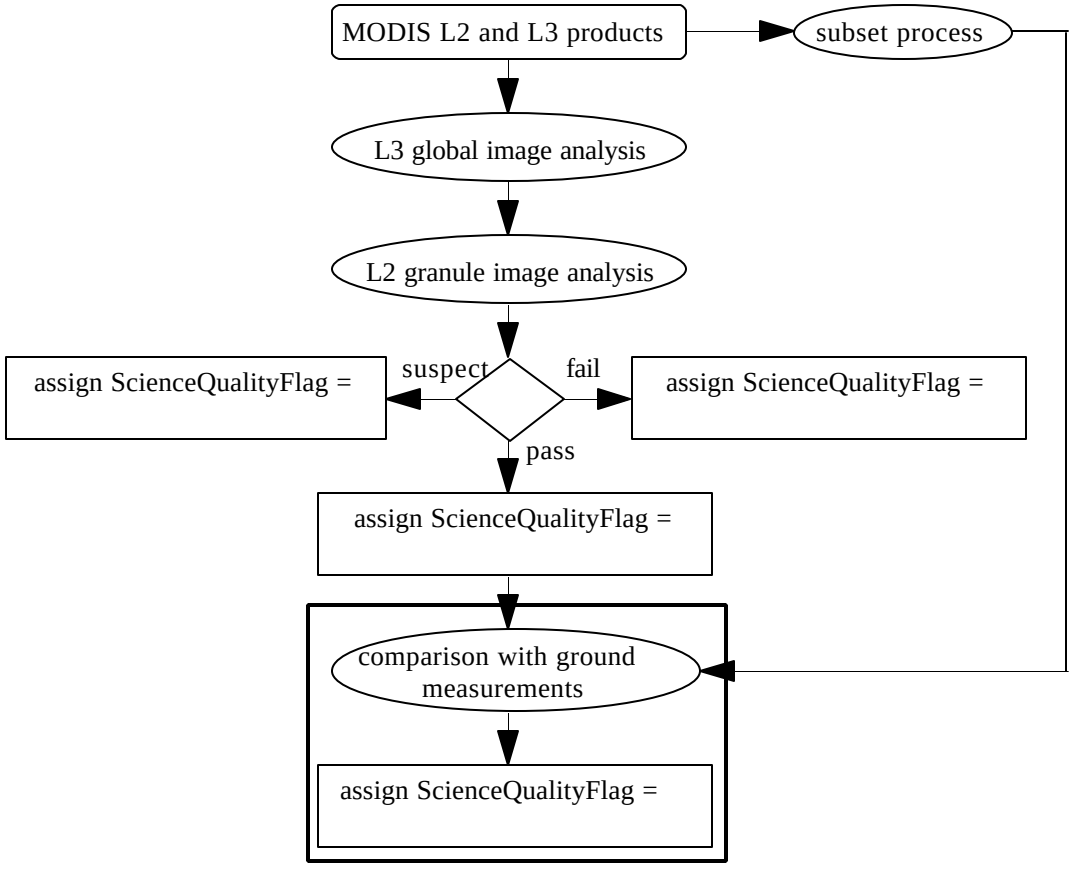
Figure 2. Interested and Golden Area for aerosols

3.1 Routine QA

An effective QA visualization system is the core of routine QA to process massive volume of the MODIS data. The critical components of the QA system include

- Level 3 product browser (Latitiude-Longitude global map)
- Level 2 product browser (histgogram, quality index)
- Level 2 product subseter
- Level 1B and ancillary data viewer

The existing visualization software, such as DIAL (reference) and Earthview (reference), can not satisfy 100% our QA needs. Our goal is to develop a system with GUI (graphic-user interface) and both interactive and batch job capabilities. For the easy software development and integration, the ENVI/IDL design structure is preferred, similar to SeaDAS (SeaWifs Data Analysis System) (reference). As a result of the routine QA process, a QA statistics report will be produced. The procedures leading to the update of granule-level science quality flag is shown below (with flags of "Passed","Failed","Suspect", "Being Investigated", "Not Investigated", Inferred Passed", "Inferred Failed" and "validated"; "Not Investigated" is the default).



3.2 Investigative QA

Investigative QA is considered to be a parallel process to routine QA. Unlike daily routine QA, the investigative QA can take indefinite time on solving the problems (e.g., anormalies) discovered in routine QA, or the inconsistency (or bias) of the products (i.e., time series). In a broader sense, it can be seen as a part of data validation effort. Of particular interest are the special events, for example the golden area for aerosols shown in Figure 2, where the deficiency of algorithm (if any) can be easily detected based upon the experience of pre-launch field experiments (e.g., SCAR-A, SCAR-B, SCAR-C, TARFOX). Table 3 shows special events of interest for MODIS atmosphere products.

Table 3. Special events for investigative QA

Atmospheric Product	Special events
Aerosol over land and ocean	**Land:** Biomass burning in Brazil and central Africa in dry season (August-September); Sulfate aerosol in the summer in the mid-Atlantic US; Outbreak of Sahara or Gobi dusts **Ocean:** Saharan dust, marine aerosol
Cloud properties	**Cirrus cloud**: Mid-western states of the US (Oklahoma to Nebraska) in the summer.
	Stratus cloud : Off coast of California and in the Arctic region, especially in June and July.
Total ozone	Antarctic ozone hole; Arctic ozone depletion; ozone depletion over North America and Europe.
Total precipitable water	Over bright surfaces (cloud and bright surfaces)

Data from other satellites can also be used for (qualitative) comparisons. These independent sources of information will provide useful to MODIS products. Table 4 lists the satellite data available at MODIS launch.

Table 4. Satellite data available for intercomparison with MODIS atmosphere products.

Product	Atmospheric Product	Satellite data
MOD04	Aerosol over land and ocean	POLDER (ADEOS), MISR, TOMS (ADEOS, EP), AVHRR, GOES
MOD05	Total precipitable water	NVAP
MOD06	Cloud properties	GOES, MISR

MOD07	Total ozone	SBUV (TOVS), TOMS (ADEOS, EP)
	Temperature and moisture profile	NCEP, DAO, NVAP
MOD35	Cloud Mask	GOES, MISR

In addition to climatological data, some operational ground sites can provide useful measurements for quantitative comparisons, which are also useful for our investigation. Thus data around Sun photometer sites (a total of 100 and % operational year-round) are subset and stored for statistical analysis in real time. The AERONET sunphotometer equipped with satellite network communication capability can efficiently calibrate and analyze data to meet our QA needs for aerosol optical thickness (at 0.34, 0.38, 0.44, 0.66, 0.86 and 1.02 ?m) and total precipitable water. Finally, after the release of the data, user's feedback is expected to play an important role in data quality assessment.

Appendix A: Table of Run Time QA Flags of MODIS Level 2 Atmospheric Products

MOD04

For the aerosol product, the run time QA flags are stored in six bytes for both land and ocean. The first byte contains the cloud mask QA flags, and the remainding five bytes (a separate array from the cloud mask QA) contain product qualitym flags, retrieval processing flags, and input data resource flags which are designed separately for land and ocean because of the differences of retrieval algorithms.

- Spatial resolution: 10?10 km
- Processing mode: Day time mode only

Cloud mask QA flags

Flag name	Number of bits	Bit value	Description
Cloud mask summary flag	1	0 1	Undetermined Determined
Cloud mask quality flag	2	0 1 2 3	0-30% cloudy pixels 30-60% cloudy pixels 60-90% cloudy pixels >90% cloudy pixels
Day / Night flag	1	0 1	Night Day
Sun glint flag	1	0 1	Yes No
Snow / Ice flag	1	0 1	Yes No
Land / Sea flag	2	0 1 2 3	Water (Ocean and Lake) Coastal Desert Land

Product quality and retrieval processing QA flags over land

Product quality QA flags			
Summary quality flag for aerosol optical thickness at 0.47 ?m	1	0 1	Not useful Useful
Estimated quality flag of aerosol optical thickness at 0.47 ?m	3	0 1 2 3 4-7	Bad (Fill Value) Marginal Good Very Good Not Used (TBD)
Summary quality flag for aerosol optical thickness at 0.66 ?m	1	0 1	Not useful Useful
Estimated quality flag of aerosol optical thickness at 0.66 ?m	3	0 1 2 3 4-7	Bad (Fill Value) Marginal Good Very Good Not Used (TBD)
Retrieval processing QA flags - Processing path flags			
Dark target criteria used in retrieval	3	0 1 2 3 4 5 6-7	not met (Fill Value) 0.01<Ref(2.1 ?m)=0.05 0.005<Ref(3.8 ?m)=0.025 0.05<Ref(2.1 ?m)=0.10 0.10<Ref(2.1 ?m)=0.15 0.10<Ref(2.1 ?m)=0.20 Spare
Error code - Fill values filled	3	0 1 2 3 4 5 6 7	No error Solar and illumination angles out of bound in look-up table Apparent reflectance measured out of bound in look-up table Number of cloud and water free pixels not met Thresholds of 2.1 ?m not met Thresholds of 3.8 ?m not met Thin cirrus detection not met Spare
High solar zenith angle (> 72°)	1	0 1	No Yes

Increased spatial resolution (5x5 km)	1	0 1	No Yes
Aerosol Type	2	0 1 2 3	Continental Dust Sulfate Smoke
Thin cirrus or stratospheric aerosol index	2	0 1 2 3	0 <? (1.38 ?m) < 0.01; correction is done ? (1.38 ?m) < 0; No correction ? (0.66 ?m) <0.04; No correction ? (1.38 ?m) >0.01; No correction
Retrieval processing QA flags - Input data resource flags			
Total ozone	2	0 1 2 3	TOVS TOMS Climatology DAO
Total precipitable water	2	0 1 2 3	NCEP/GDAS MOD05 - NIR Climatology DAO
Snow cover	2	0 1 2-3	MOD35-cloud mask MOD10-L3 8 day product. TBD
Spare	6		TBD

Product quality and retrieval processing QA flags over ocean

Product run time QA flags			
Summary quality flag	1	0 1	Not useful Useful
Estimated quality of aerosol parameters of best solution	3	0 1 2 3 4-7	Bad Marginal Good Very Good Not Used (TBD)
Summary quality flag	1	0 1	Not useful Useful

Estimated quality of aerosol parameter of average solution	3	0 1 2 3 4-7	Bad Marginal Good Very Good Not Used (TBD)
Retrieval processing QA flags - Processing path flags			
Part I: retrieving condition flags when inversion is not performed - ??????hm) fill value will be output	4	0 1 2 3 4 5 6 7 8 9 10-15	(Retrieval is performed)? Glitter is present. Cloudy. Ref (0.865 ? m) too low for retrieving optical thickness. Total number of available visible / swir (from 550 to 1240 nm) wavelengths is insufficient. Total number of available wavelengths <3. Angles out of bounds. Land present in 10x10 km box. ???????hm) < -0.01; algorithm found negative values of optical thickness (there is a problem). ???????hm) > 3; out of bound in lookup table TBD

Part II: retrieving condition flags when inversion is performed - retrieved value will be output	4	0 1 2 3 4 5 6 7 8 9 10 11 12-15	(Retrieval performed normally) Number of useful pixels within 10?10 km box is <10%. Ref (0.865 ?m) low but large enough for retrieving optical thickness. The size distribution is questionable; ? = fill valu.e 2.13 ?m channel not used. 1.65 ?m channels not used 2.13 and 1.65 ?m channels not used Aerosol type as well as aerosol content are variable. There is variability in aerosol content but the spectral dependence is stable. The best value of ? is larger than the threshold value (=5%). ??????????????hm) < 0 but to avoid bias in level 3 product. Glint angle between 40° and 50° No retrieval TBD
Retrieval processing QA flags - Input data resource flags			
Total ozone	2	0 1 2 3	TOMS TOVS DAO Climatology
Total precipitable water	2	0 1 2 3	NCEP MOD05 - NIR DAO MOD05 - IR
Snow cover	2	0 1 2 3	No snow detected MOD35-cloud mask MOD10-L3 8 day product. Other
Spare	2	0-3	TBD
Spare	8	0-7	TBD

MOD05

The total precipitable water product combines results from both the NIR (1?1 km) and IR algorithms (5?5 km). For near infrared (NIR) total precipitable water, the first byte contains cloud mask QA (1?1 km), and the second byte (a separate array from the cloud mask QA) contains NIR product quality and retrieval processing flags. For the five bytes of IR total precipitable water results, only product quality and retrieval processing flags are stored. Since IR total precipitable water results are copied from MOD07, the cloud mask related QA flags can be retrieved from MOD07, and therefore it will not be duplicated here in MOD05 product.

- Spatial resolution: 1?1 km (NIR) and 5?5 km (IR)
- Processing mode: Day time only (NIR) and Day and Night (IR)

Cloud mask QA flags (1x1 km only)

QA flags name	Number of bits	Bit value	Description
cloud mask	1	0	Determined
		1	Undetermined
	2	0	Cloudy
		1	66% clear
		2	95% clear
		3	99% clear
Day / Night flag	1	0	Night
		1	Day
Sun glint flag	1	0	Yes
		1	No
Snow / Ice flag	1	0	Yes
		1	No
Land / Sea flag	2	0	Water (Ocean)
		1	Coastal
		2	Desert
		3	Land

Total Precipitable Water - NIR

Product quality and retrieval processing QA flags

Product quality QA flags

Summary quality flag	1	0 1	Not useful Useful
Estimated quality flag of total precipitable water (NIR)	3	0 1 2 3 4-7	Bad Marginal Good Very good Not Used (TBD)
Retrieval processing QA flags - processing path flags			
Inversion method used (NIR)	2	0 1 2 3	Two channel ratio Three channel ratio No retrieval Spare
Surface type	2	0 1 2 3	(Bright) land surface Sea Cloud Glint

Total Precipitable Water - IR

Product quality and retrieval processing QA flags

Product quality QA flags			
IR Water Vapor QA	1	0 1	Not useful Useful
IR Water Vapor Confidence QA (IR)	3	0 1 2 3 4-7	Bad Marginal Good Very Good Not Used (TBD)
Spares	4		
Retrieval processing QA flgas - processing path flags			
Number of Cloudy Pixels within 5x5 km box	Int 8	0-25	TBD
Number of Clear Pixels within 5x5 km box	Int 8	0-25	TBD
Number of Missing Pixels within 5x5 km box	Int 8	0-25	TBD

IR Water Vapor Retrieval Method Used	2	0 1 2 3	Split Window (11-12) tecnhique Integration of Moisture Profile Other No Retrieval
Spares	6		

MOD06

The MODIS cloud product consists of both a 1 km set of parameters derived from solar reflectance channels and a 5 km set of parameters determined from thermal emitted channels.

Cloud Properties

The solar reflectance cloud product, cloud properties, QA flags are stored in six bytes. The first byte contains cloud mask QA flags, which is a copy of the first byte of the MOD35 cloud mask product. The remaining five bytes (a separate array from the cloud mask QA) contain the product quality flags, retrieval processing flags, and input data resource flags.

- Spatial resolution: 1?1 km
- Processing mode: Day time mode only

Common run time QA (Cloud Mask) flags

QA Flag Name	Number of Bits	Bit Value	Description
Cloud Mask	1	0 1	Undetermined Determined
Cloud Mask Quality Flag	2	0 1 2 3	Cloudy > 66% confident clear > 95% confident clear > 99% confident clear
Day / Night flag	1	0 1	Night Day
Sun glint flag	1	0 1	Yes No
Snow / Ice flag	1	0 1	Yes No
Land / Water flag	2	0 1 2 3	Water (ocean) Coastal Desert Land

Product quality and retrieval processing QA flags

Product quality QA flags			
Optical Thickness General QA	1	0 1	not useful useful
Optical Thickness Confidence QA	2	0-3	4 confidence levels*

Optical Thickness out-of-bounds	2	0 1 2 3	Within bounds (? = 100) 100 < ? < 150 150 < ? < 200 ? > 200
Effective Radius General QA	1	0 1	not useful useful
Effective Radius Confidence QA	2	0-3	4 confidence levels*
Liquid Water Path General QA	1	0 1	not useful useful
Liquid Water Path Confidence QA	2	0 1 2 3	4 confidence levels*
Cloud Phase Determination (SWIR)	3	0 1 2 3 4	Fill Value (no retrieval made) Clear Cloud, water Cloud, ice Cloud, mixed phase of undertermined
Spare	2	0-3	TBD
Retrieval processing QA flags - processing path flags			
Cloud Phase used in retrieval processing Path	3	0 1 2 3 4 5	Fill Value(missing data, no info ...) Clear* Cloud, water Cloud, ice Cloud, mixed phase Cloud, undetermined (Clear* vs cloudy determined from a subset of cloud mask tests; phase processing path determined from cloud mask, IR, and SWIR tests)
Rayleigh Correction	1	0 1	No Yes
Water Vapor Correction	1	0 1	No Yes
Band Used for Optical Thickness Retrieval	2	0 1 2 3	Not retrieved 0.645 µm (land) 0.858 µm (water) 1.24 µm (snow / ice)
Spare	1		
Retrieval processing QA flags - input data resource flags			
Total precipitable water	2	0 1 2 3	NCEP GDAS DAO MOD05 - NIR MOD07 - IR

Moisture profile	2	0 1 2 3	NCEP GDAS DAO AIRS / AMSU Other
Cloud Top Height	2	0 1 2 3	MOD06 (Menzel) DAO Other Not used
Temperature Profile	2	0 1 2 3	NCEP GDAS DAO AIRS / AMSU Other
Surface Temperature Over Land	2	0 1 2 3	NCEP GDAS DAO MOD11 Not used
Surface Temperature Over Ocean	2	0 1 2 3	Reynolds Blended NCEP DAO MOD28
BRDF / Albedo	2	0 1 2 3	MOD43 DAO CERES Other
Ozone profile	2	0 1 2 3	TOMS TOVS DAO Other

* Only 4 confidence levels (0-3) are currently utilized:

0 : Bad
1 : Marginal
2 : Good
3 : Very Good

Cloud Top Properties

Cloud top properties, the thermal emitted contribution to the cluod product, QA flags are stored in eleven bytes. The first byte consists of the cloud mask QA flags, which are determined based upon a 5?5 km spatial resolution. The remaining ten bytes contain the product quality flags, retrieval processing flags, and input data resource flags.

- Spatial resolution: 5?5 km
- Processing mode: Daytime and Nighttime modes

Common run time QA (Cloud Mask) flags: (Some combination of 5x5- 1 km values)

QA Flag Name	Number of Bits	Bit Value	Description
Cloud Mask	1	0 1	Undetermined Determined
Cloud Mask Quality Flag	2	0 1 2 3	0-20% cloudy pixels 20-40% cloudy pixels 40-60% cloudy pixels 60-100% cloudy pixels
Day / Night flag	1	0 1	Night Day
Sun glint flag	1	0 1	Yes No
Snow / Ice flag	1	0 1	Yes No
Land / Water flag	2	0 1 2 3	Water (ocean) Coastal Desert Land

Product quality and retrieval processing QA flags

Product quality QA flags			
Cloud Top Pressure QA	1	0 1	not useful useful
Cloud Top Pressure Confidence QA	3	0-7	8 confidence levels*
Cloud Top Temperature QA	1	0 1	not useful useful

Cloud Top Temperature Confidence QA	3	0-7	8 confidence levels*
Cloud Fraction QA	1	0 1	not useful useful
Cloud Fraction Confidence QA	3	0-7	8 confidence levels*
Cloud Effective Emissivity QA	1	0 1	not useful useful
Cloud Effective Emissivity Confidence QA	3	0-7	8 confidence levels*
Cloud Phase Infrared QA	1	0 1	not useful useful
Cloud Phase Infrared Confidence QA	3	0-7	8 confidence levels*
Retrieval processing QA flags - processing path flags			
Cirrus Level 3 flag	2	0 1 2	0 - missing 1 - no cirrus found 2 - cirrus found
High cloud Level 3 flag	2	0 1 2	0 - missing 1 - no high cloud found 2 - high cloud found
Number of Cloudy Pixels within 5x5 km box	Int 8	0-25	
Number of Clear Pixels within 5x5 km box	Int 8	0-25	
Number of Missing Pixels within 5x5 km box	Int 8	0-25	
Maximum Likelihood Estimator	1	0 1	Not used Invoked
Cluster analysis	1	0 1	Not used Invoked
Goodness of Fit	1	0 1	0 = < 1 0 = 1
$?^2$	1	0 1	< npts used in MLE > npts used in MLE
Spares?	2		
Retrieval processing QA flags - input data resource flags			

Clear Radiance Origin	2	0 1 2 3	MOD35 Forward calculation from model (NCEP GDAS) other Not used
Moisture profile	2	0 1 2 3	NCEP GDAS DAO AIRS/AMSU Other
Temperature Profile	2	0 1 2 3	NCEP GDAS DAO AIRS/AMSU Other
Surface Temperature Over Land	2	0 1 2 3	NCEP GDAS DAO MOD11 Other
Surface Temperature Over Ocean	2	0 1 2 3	Reynolds blended DAO MOD28 Other
Surface Pressure	2	0 1 2 3	NCEP GDAS DAO Other Not used
Topography	2	0 1	EOS DEM Other
Surface Emissivity	2	0 1	CERES MOD11
Surface Type	2	0 1 2 3	Loveland 1km NA Olson Ecosystem MOD12 Other
Spares	8		

* Only 4 confidence levels (0-3) are currently utilized:

0 : Bad
1 : Marginal
2 : Good
3 : Very Good

MOD07

For atmospheric profiles, stability and total ozone product, the QA flags are stored in eleven bytes. The first byte contains cloud mask QA flags which are determined based upon ??? km spatial resolution. The remaining ten bytes contain the product quality flags, retrieval processing flags and input data resource flags.

- Spatial resolution: 5?5 km
- Processing mode: Daytime and Nighttime modes

Common run time QA (Cloud Mask) flags: (Some combination of 5x5- 1 km values)

QA Flag Name	Number of Bits	Bit Value	Description
Cloud Mask	1	0 1	Undetermined Determined
Cloud Mask Quality Flag	2	0 1 2 3	0-20% cloudy pixels 20-40% cloudy pixels 40-60% cloudy pixels 60-100% cloudy pixels
Day / Night flag	1	0 1	Night Day
Sun glint flag	1	0 1	Yes No
Snow / Ice flag	1	0 1	Yes No
Land / Water flag	2	0 1 2 3	Water (ocean) Coastal Desert Land

Product quality and retrieval processing QA flags

Product quality QA flags			
Retrieved Temperature Profile QA	1	0 1	not useful useful
Retrieved Temperature Profile Confidence QA	3	0-7	8 confidence levels*
Retrieved Moisture Profile QA	1	0 1	not useful useful

Retrieved Moisture Profile Confidence QA	3	0-7	8 confidence levels*
Total Ozone Burden QA	1	0 1	not useful useful
Total Ozone Burden Confidence QA	3	0-7	8 confidence levels*
Stability Indices (Lifted Index) QA	1	0 1	not useful useful
Stability Indices (Lifted Index) Confidence QA	3	0-7	8 confidence levels*
Stability Indices (K Index) QA	1	0 1	not useful useful
Stability Indices (K Index) Confidence QA	3	0-7	8 confidence levels*
Stability Indices (Total Totals) QA	1	0 1	not useful useful
Stability Indices (Total Totals) Confidence QA	3	0-7	8 confidence levels*
Retrieval processing QA flags - processing path flags			
Number of Cloudy Pixels within 5x5 km box	Int 8	0-25	
Number of Clear Pixels within 5x5 km box	Int 8	0-25	
Number of Missing Pixels within 5x5 km box	Int 8	0-25	
Method of Profiles Retrieval	2	0 1 2 3	Statistical Physical Other No retrieval
Method of Ozone Retrieval	2	0 1 2 3	RTE Perturbation Upper and Lower stratospheric ozone method Other No retrieval
Spares	4		
Retrieval processing QA flags - Input data resource flags			

Guess Moisture profile	2	0 1 2 3	NCEP GDAS DAO AIRS/AMSU Other
Guess Temperature Profile	2	0 1 2 3	NCEP GDAS DAO AIRS/AMSU Other
Surface Temperature Over Land	2	0 1 2 3	NCEP GDAS DAO MOD11 Not used
Surface Temperature Over Ocean	2	0 1 2 3	Reynolds blended DAO MOD28 Other
Surface Pressure	2	0 1 2 3	NCEP GDAS DAO Other Not used
Ozone First Guess Profile	2	0 1 2 3	TOMS TOVS DAO Other
Spares	12		

* Only 4 confidence levels (0-3) are currently utilized:

0 : Bad
1 : Marginal
2 : Good
3 : Very Good

MOD35

The cloud mask product consists of 10 bytes product quality and processing flags.

- Spatial resolution: 1?1 km and 250?250 m
- Processing mode: Daytime and nighttime modes

Common run time QA (Cloud Mask) flags. Found within cloud mask product itself.

Product quality and processing QA flags

Product quality QA flags			
Cloud Mask QA (1km)	1	0 1	not useful useful
Cloud Mask Confidence QA (1km)	3	0-7	8 confidence levels*
Spares	4		
Processing QA flags - Individual test application			
NCO test	1	0 1	Not Applied Applied
Thin Cirrus test (Solar)	1	0 1	Not Applied Applied
Shadow Detection tests	1	0 1	Not Applied Applied
Thin Cirrus test (IR)	1	0 1	Not Applied Applied
Cloud Adjancency Test	1	0 1	Not Applied Applied
IR Threshold test	1	0 1	Not Applied Applied
High Cloud Test (CO2)	1	0 1	Not Applied Applied
High Cloud Test (6.7 ?m)	1	0 1	Not Applied Applied
High Cloud Test (1.38 ?m)	1	0 1	Not Applied Applied
High Cloud Test (3.7-12?m)	1	0 1	Not Applied Applied
IR Temperature Difference Tests	1	0 1	Not Applied Applied
3.7-11?m Test	1	0 1	Not Applied Applied
.68 Reflectance Test	1	0 1	Not Applied Applied

Visible Ratio Test	1	0 1	Not Applied Applied
Near IR Reflectance Ratio Test	1	0 1	Not Applied Applied
3.7-3.9 ?m Test	1	0 1	Not Applied Applied
Temporal Consistency Test	1	0 1	Not Applied Applied
Spatial Variability Test	1	0 1	Not Applied Applied
Spare	6		
250 m Visible Tests (Repeated 16 times)	1(16)	0 1	Not Applied Applied
Processing QA flags - Input data information flags			
Number of bands used to generate cloud mask	2	0 1 2 3	None 1-7 8-14 15-21
Number of spectral tests used to generate cloud mask	2	0 1 2 3	None 1-3 4-6 7-9
Spares	4		
Processing QA flags - Input data resource flags			
Clear Radiance Origin	2	0 1 2 3	MOD35 Forward calculation from NCEP GDAS model Other Not Used
Surface Temperature Over Land	2	0 1 2 3	NCEP GDAS DAO MOD11 Other
Surface Temperature Over Ocean	2	0 1 2 3	Reynolds blended DAO MOD28 Other
Surface Winds	2	0 1 2 3	NCEP GDAS DAO Other Not Used
Ecosystem Map	2	0 1 2 3	Loveland NA 1km Olson Ecosystem MOD12 Other

Snow mask	2	0 1 2 3	MOD33 SSMI product Other Not used
Ice cover	2	0 1 2 3	MOD42 SSMI product Other Not used
Land / Sea Mask	2	0 1 2 3	USGS 1 km 6 level USGS 1 km binary Other Not used
Digital Elevation Model	1	0 1	EOS DEM Not used
Precipitable Water	2	0 1 2 3	NCEP GDAS DAO MOD07 Not used
Spare	5		

* Only 4 confidence levels (0-3) are currently utilized:

0 : Bad
1 : Marginal
2 : Good
3 : Very Good

Appendix B: Table of QA Product Specific Attributes (Non-ECS Inventory Metadata) of MODIS Level 2 Atmospheric Products

MOD04

Field Name	Data Type	Field Description	Source
AdditionalAttributeName.1	String	SuccessfulRetrievalPct_Land	PGE / alg
AdditionalAttributeName.2	String	SuccessfulRetrievalPct_Ocean	PGE / alg
AdditionalAttributeName.3	String	LowConfidentClearPct	PGE / alg
AdditionalAttributeName.4	String	DayProcessedPct	PGE / alg
AdditionalAttributeName.5	String	NightProcessedPct	PGE / alg
AdditionalAttributeName.6	String	SunglintProcessPct	PGE / alg
AdditionalAttributeName.7	String	Snow_IceSurfaceProcessPct	PGE / alg
AdditionalAttributeName.8	String	LandProcessedPct	PGE / alg
AdditionalAttributeName.9	String	WaterProcessedPct	PGE / alg
AdditionalAttributeName.10	String	ShadowProcessedPct	PGE / alg
AdditionalAttributeName.11	String	ThinCirrusSolar_FoundPct	PGE / alg
AdditionalAttributeName.12	String	ThinCirrusIR_FoundPct	PGE / alg
AdditionalAttributeName.13	String	NonCloudObstructionPct	PGE / alg
AdditionalAttributeName.14	String	MaxSolarZenithAngle	PGE / alg
AdditionalAttributeName.15	String	MinSolarZenithAngle	PGE / alg
AncillaryInputType	String	“Geolocation”	PGE / pcf
AncillaryInputTypePointer	String	UR of geolocation granule	PGE / pcf
PlatformShortName	String	“EOS-AM1”	PGE / pcf
InstrumentShortName	String	“MODIS”	PGE / pcf

PGE: Product Generation Exectable; pcf: process control file; alg : algorithm

MOD05

Field Name	Data Type	Field Description	Source
AdditionalAttributeName.1	String	SuccessfulRetrievalPct_NIR	PGE / alg
AdditionalAttributeName.2	String	SuccessfulRetrievalPct_IR	PGE / alg
AdditionalAttributeName.3	String	LowConfidentClearPct	PGE / alg
AdditionalAttributeName.4	String	CloudPct_IR	PGE / alg
AdditionalAttributeName.5	String	DayProcessedPct	PGE / alg
AdditionalAttributeName.6	String	NightProcessedPct	PGE / alg
AdditionalAttributeName.7	String	SunglintProcessPct	PGE / alg
AdditionalAttributeName.8	String	Snow_IceSurfaceProcessPct	PGE / alg
AdditionalAttributeName.9	String	LandProcessedPct	PGE / alg
AdditionalAttributeName.10	String	WaterProcessedPct	PGE / alg
AdditionalAttributeName.11	String	ShadowProcessedPct	PGE / alg
AdditionalAttributeName.12	String	ThinCirrusSolar_FoundPct	PGE / alg
AdditionalAttributeName.13	String	ThinCirrusIR_FoundPct	PGE / alg
AdditionalAttributeName.14	String	NonCloudObstructionPct	PGE / alg
AdditionalAttributeName.15	String	MaxSolarZenithAngle	PGE / alg
AdditionalAttributeName.16	String	MinSolarZenithAngle	PGE / alg
AncillaryInputType	String	“Geolocation”	PGE / pcf
AncillaryInputTypePointer	String	UR of geolocation granule	PGE / pcf
PlatformShortName	String	“EOS-AM1”	PGE / pcf
InstrumentShortName	String	“MODIS”	PGE / pcf

PGE: Product Generation Exectable; pcf: process control file; alg : algorithm

MOD06

Field Name	Data Type	# of Value	Value
AdditionalAttributeName.1	String	1	SuccessCloudTopPropRetrPct_IR
AdditionalAttributeName.2	String	1	SuccessCloudPhaseRtrRetPct_IR
AdditionalAttributeName.2	String	1	SuccessCloudOpticalPropRtrPct_IR
AdditionalAttributeName.3	String	1	LowCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	MidCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	HighCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	ThinCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	ThickCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	OpaqueCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	CirrusCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	IceCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	WaterCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	MixedCloudDetectedPct_IR
AdditionalAttributeName.4	String	1	CloudPhaseUncertainPct_IR
AdditionalAttributeName.4	String	1	OceanCoverFractionPct
AdditionalAttributeName.4	String	1	LandCoverFractionPct
AdditionalAttributeName.4	String	1	SnowCoverFractionPct
AdditionalAttributeName.4	String	1	CloudCoverFractionPct_VIS
AdditionalAttributeName.5	String	1	WaterCloudFractionPct_VIS
AdditionalAttributeName.6	String	1	IceCloudDetectedPct_VIS
AncillaryInputType	String	1	“Geolocation”
AncillaryInputTypePointer	String	1	UR of geolocation granule
PlatformShortName	String	1	“EOS-AM1”
InstrumentShortName	String	1	“MODIS”

MOD07

Field Name	Data Type	# of Value	Value
AdditionalAttributeName.1	String	1	SuccessfulRetrievalPct
AdditionalAttributeName.2	String	1	LowConfidenceClearPct
AdditionalAttributeName.3	String	1	DayProcessedPct
AdditionalAttributeName.4	String	1	NightProcessedPct
AdditionalAttributeName.5	String	1	SunglintProcessPct
AdditionalAttributeName.6	String	1	Snow_IceSurfaceProcessPct
AdditionalAttributeName.7	String	1	LandProcessedPct
AdditionalAttributeName.8	String	1	WaterProcessedPct
AdditionalAttributeName.9	String	1	ShadowProcessedPct
AdditionalAttributeName.10	String	1	ThinCirrusSolar_FoundPct
AdditionalAttributeName.11	String	1	ThinCirrusIR_FoundPct
AdditionalAttributeName.12	String	1	NonCloudObstructionPct
AdditionalAttributeName.13	String	1	MaxSolarZenithAngle
AdditionalAttributeName.14	String	1	MinSolarZenithAngle
AncillaryInputType	String	1	“Geolocation”
AncillaryInputTypePointer	String	1	UR of geolocation granule
PlatformShortName	String	1	“EOS-AM1”
InstrumentShortName	String	1	“MODIS”

MOD35

Field Name	Data Type	# of Value	Value
AdditionalAttributeName.1	String	1	SuccessfulRetrievalPct
AdditionalAttributeName.2	String	1	VeryHighConfidenceClearPct
AdditionalAttributeName.3	String	1	HighConfidenceClearPct
AdditionalAttributeName.4	String	1	UncertainConfidenceClearPct
AdditionalAttributeName.5	String	1	LowConfidenceClearPct
AdditionalAttributeName.6	String	1	CloudCoverPct250m
AdditionalAttributeName.7	String	1	ClearPct250m
AdditionalAttributeName.8	String	1	DayProcessedPct
AdditionalAttributeName.9	String	1	NightProcessedPct
AdditionalAttributeName.10	String	1	SunglintProcessPct
AdditionalAttributeName.12	String	1	Snow_IceSurfaceProcessPct
AdditionalAttributeName.13	String	1	LandProcessedPct
AdditionalAttributeName.13	String	1	WaterProcessedPct
AdditionalAttributeName.14	String	1	ShadowProcessedPct
AdditionalAttributeName.15	String	1	ThinCirrusSolar_FoundPct
AdditionalAttributeName.16	String	1	ThinCirrusIR_FoundPct
AdditionalAttributeName.17	String	1	NonCloudObstructionPct
AdditionalAttributeName.18	String	1	MaxSolarZenithAngle
AdditionalAttributeName.19	String	1	MinSolarZenithAngle
AncillaryInputType	String	1	“Geolocation”
AncillaryInputTypePointer	String	1	UR of geolocation granule
PlatformShortName	String	1	“EOS-AM1”
InstrumentShortName	String	1	“MODIS”

Appendix C: Table of QA Archive Metadata of MODIS Level 2 Atmospheric Products

The product specific QA archive metadata are designed to report the statistics and information that are only needed to be archived along with science data sets of each granule.

MOD04

Field name	Data Type	No. Value	Value	Source
ALGORITHMPACKAGEACCEPTANCE DATE	String	1	"June-1997"	PGE / pcf
ALGORITHMPACKAGEMATURITYCODE	String	1	"at-launch"	PGE / pcf
ALGORITHMPACKAGENAME	String	1	"ATBD-MOD-02	PGE / pcf
ALGORITHMPACKAGEVERSION	String	1	"2"	PGE / pcf
LONGNAME	String	1	"Aerosol"	PGE / pcf
INSTRUMENTNAME	String	1	"MODIS"	PGE / pcf
LOCALINPUTGRANULEID	String	10 (max)	†	PGE / pcf / MODIS inputs
EXCLUSIONGRINGFLAG	String	M,1	variable	PGE / pcf / geo-location file
GRINGPOINTLATITUDE	Double	M,4	variable	
GRINGPOINTLONGITUDE	Double	M,4	variable	
GRINGPOINTSEQUENCENO	Integer	M,4	variable	
VeryGoodQualityPct_Land	Integer	1	variable	PGE / alg
GoodQualityPct_Land	Integer	1	variable	PGE / alg
MarginalQualityPct_Land	Integer	1	variable	PGE / alg
BadQualityPct_Land	Integer	1	variable	PGE / alg
VeryGoodQualityPct_Ocean	Integer	1	variable	PGE / alg
GoodQualityPct_Ocean	Integer	1	variable	PGE / alg
MarginalQualityPct_Ocean	Integer	1	variable	PGE / alg
BadQualityPct_Ocean	Integer	1	variable	PGE / alg
AlgorithmSoftwareVersion_Land	String	1	variable	PGE / pcf
AlgorithmSoftwareVersion_Ocean	String	1	variable	PGE / pcf

†: "MODIS product inputs using MODIS naming convention"

PGE: Product Generation Exectable; pcf: process control file; alg : algorithm

MOD05

Field name	Data type	No. of value	Value	Source
ALGORITHMPACKAGEACCEPTANCE DATE	String	1	“June-1997”	PGE / pcf
ALGORITHMPACKAGEMATURITYCODE	String	1	“at-launch”	PGE / pcf
ALGORITHMPACKAGENAME	String	1	“ATBD-MOD-03”	PGE / pcf
ALGORITHMPACKAGEVERSION	String	1	“2”	PGE / pcf
LONGNAME	String	1	“Total precipitable water”	PGE / pcf
INSTRUMENTNAME	String	1	“MODIS”	PGE / pcf
LOCALINPUTGRANULEID	String	10 (max)	†	PGE / pcf / MODIS inputs
EXCLUSIONGRINGFLAG	String	M,1	variable	PGE / pcf / geo-location file
GRINGPOINTLATITUDE	Double	M,4	variable	
GRINGPOINTLONGITUDE	Double	M,4	variable	
GRINGPOINTSEQUENCENO	Integer	M,4	variable	
AlgorithmSoftwareVersion_NIR	String	1	variable	PGE / pcf
AlgorithmSoftwareVersion_IR	String	1	variable	PGE / pcf

†: “MODIS product inputs using MODIS naming convention”

PGE: Product Generation Exectable; pcf: process control file; alg : algorithm

MOD06

Field name	Data type	No. of value	Value
ALGORITHMPACKAGEACCEPTANCE DATE	String	1	“June-1997”
ALGORITHMPACKAGEMATURITYCODE	String	1	“at-launch”
ALGORITHMPACKAGENAME	String	1	“ATBD-MOD-04 and ATBD-MOD-05”
ALGORITHMPACKAGEVERSION	String	1	“2”
INSTRUMENTNAME	String	1	“MODIS”
PLATFORMSHORTNAME	String	1	“EOS-AM1”
LONGNAME	String	1	“Total precipitable water”
LOCALINPUTGRANULEID	String	10	†
EXCLUSIONGRINGFLAG	String	M,1	variable
GRINGPOINTLATITUDE	Double	M,4	variable
GRINGPOINTLONGITUDE	Double	M,4	variable
GRINGPOINTSEQUENCENO	Integer	M,4	variable
Algorithm_Version_Cloud_Top_Property_IR	String	1	variable
Algorithm_Version_Cloud_Phase_IR	String	1	variable
Algorithm_Version_Cloud_Property_VIS	String	1	variable

† “MODIS product inputs using MODIS naming convention”

MOD07

Field name	Data type	No. of value	Value
INSTRUMENTNAME	String	1	“MODIS”
PLATFORMSHORTNAME	String	1	"EOS-AM1"
LONGNAME	String	1	"MODIS Level 2 Profiles"
ALGORITHMPACKAGEACCEPTANCE DATE	String	1	“June-1997”
ALGORITHMPACKAGEMATURITYCODE	String	1	“at-launch”
ALGORITHMPACKAGENAME	String	1	“ATBD-MOD-07"
ALGORITHMPACKAGEVERSION	String	1	“2”
LOCALINPUTGRANULEID	String	10	†
EXCLUSIONGRINGFLAG	String	M,1	variable
GRINGPOINTLATITUDE	Double	M,4	variable
GRINGPOINTLONGITUDE	Double	M,4	variable
GRINGPOINTSEQUENCENO	Integer	M,4	variable
Profiles_Algorithm_Version_Number	String	1	version number
Total_Ozone_Algorithm_Version_Number	String	1	version number
Stability_Indices_Algorithm_Version_Number	String	1	version number

† “MODIS product inputs using MODIS naming convention”

MOD35

Field name	Data type	No. of value	Value
INSTRUMENTNAME	String	1	†
LONGNAME	String	1	!
ALGORITHMPACKAGEACCEPTANCE DATE	String	1	“June-1997”
ALGORITHMPACKAGEMATURITYCODE	String	1	“at-launch”
ALGORITHMPACKAGENAME	String	1	“ATBD-MOD-06”
ALGORITHMPACKAGEVERSION	String	1	“2”
LOCALINPUTGRANULEID	String	10	*
EXCLUSIONGRINGFLAG	String	M,1	variable
GRINGPOINTLATITUDE	Double	M,4	variable
GRINGPOINTLONGITUDE	Double	M,4	variable
GRINGPOINTSEQUENCENO	Integer	M,4	variable
Cloud_Mask_Algorithm_Version_Number	Integer	1	variable

† “Moderate Resolution Imaging Spectrometer”
! “MODIS cloud mask and spectral test results”
* “MODIS product inputs using MODIS naming convention”